Felsic to intermediate hypabyssal intrusive rocks - dikes, sills, and small stocks intrude most pre-Miocene map units. Dikes and sills are very conspicuous in domains 2 and 4; small stocks are most numerous in domain 3, but exist in all domains The hypabyssal rocks are compositionally diverse: dacite predominates but rocks ranging from rhyodacite to quartz latite and andesite are present locally. Most rocks are porphyritic and contain abundant fine-grained (or less commonly mediumgrained) phenocrysts in extremely fine-grained felted or pilo-taxitic groundmasses. The phenocrysts consist of plagioclase, mafic minerals (chiefly hornblende), and less commonly of are represented by chloritized pseudomorphs or relics and the feldspar phenocrysts are partially albitized or replaced by calcite or sericite. Groundmasses generally are strongly altered also. The hypabyssal rocks form bold, conspicuous light-colored outcrops and weather very light gray or pale can

that affected the Valdez terrane and contiguous terranes to the north; they also may post-date major movement on the Spirit Mountain and Tazlina faulte inasmuch as they intrude rocks both north and south of the faults. Samples from domains 2 and 4 (Table 1, locs. 12 and 29) have been dated at ca. 47 and 52 m.y., indicating an Eocene age for some of the hypabyssal the west (Mitchell and others, 1981) and numerous plutons that intrude the Valdez and Orca Groups in the Prince William Sound have similar Eocene ages. Hypabyssal rocks in domain 3 sre undeted; they are similar to undated rocks in the Nelchine undated rocks in the upper Matanuska Valley and the southern Talkeetna Mountains that intrude rocks as young as the Chick and have numerous K-Ar ages in the range of 50 to 40 m.y. (A. Grantz and M. L. Silberman, unpublished data, 1980). To the east in the McCarthy quadrangle, similar rocks in domain I have yielded K-Ar ages as young as Pliocene (MacKevett and others, 1978) and are believed to represent subvolcanic phases of Wrangell Lava volcanism; analogous rocks may be present ithe southern Talkeetna Mountains (Csejtey and others, 1978).

> DOMAIN 1 Sedimentary and volcanic rocks

Wrangell Lava - The Wrangell Lava (Mendenhall, 1905) consists of at least 2,000 m of flows, tephra, and minor sedimentary rocks in the northeastern part of the quadrangle. The volcanic rocks issued chiefly from Mt. Wrangell (4317 m), an active shield volcano, which emits small quantities of ash intermittently from a satellitic crater on the west rim of its summit caldera. sequence; and columnar jointed to massive flows and tephra are interstratified with Holocene ash- and debris-flows as far as 0 km from the summit of Mt. Wrangell (Miller and Smith, 1976; Yehle and Nichols, 1980). The Wrangell Lava ranges in composition from baselt to dacite, but mainly is pyroxene andesite. The flows are texturally diverse: porphyritic rocks with fin grained intersertal groundmasses are characteristic, but vitrophyres and agglutinates are common also. The pyroclastic rocks range from agglomerate to ash and are dominantly lithiccrystal tuff. Widespread but volumetrically minor mud and debris flows and gravelly tillites(?) are exposed beneath flows in river canyons that drain southwestward from Mt. Wrangell. The Wrangell Lava is part of a calc-alkaline volcanic province that extends throughout the Wrangell Mountains and discontinuously eastward into the Yukon Territory (MacKevett, 1978).

Probable correlatives occur in the Talkeetna Mountains, the Alaska Peninsula, and the Aleutian Islands. Most Wrangell Lava in the Valdez quadrangle is thought to be Quaternary in asmuch as Denton and Armstrong (1969) report K-Ar ages ranging between 10 and 2.7 m.y. for Wrangell Lava in the

Nabesna quadrangle to the northeast. The youngest Wrangell Lava in the Valdez quadrangle is not well dated, but probably

is Holocene inasmuch as parts of the courses of several rivers

in the southern Copper River Basin appear to have been influe

ced by Wrangell Lava flows which lie above dated ash- and debris-flows that have a minimum C-14 age of only 1760 ± 200 years (Miller and Smith, 1976). Berg Creek Formation - Lower Cretaceous marine clastic rocks are exposed in three separate areas of domain 1: (1) at the eastern edge of the quadrangls capping a ridge between the Kotsina River and Long Glacier; (2) near the confluence of the west and south of Nerelna Creek. The Lower Cretaceous rocks Mesozoic bedded rocks and upon Upper Jurassic plutonic rocks dated by K-Ar at 153 + 5 m.y. (Table 1, loc. 6). North of the stone and siltstone, and calcarenite (Grantz and others, 1966).
The basal strata generally are pebble, cobble, and boulder conglomerate consisting of clasts that were derived from nearby bedrock. Overlying strata are very lenticular, and many sandstone beds have steeply inclined cross-stratification Most of the clastic rocks are glauconitic, fossiliferous, or thick Inoceramus shells and calcareous sandstone crowded with Inoceramus prisms are present (Grantz and others, 1966). The abundance of siltstone probably indicates that the rocks were deposited farther from shore than the thinner and coarser

clastic rocks are present in domain 3 to the west of the Valdez quadrangle in the Talkeetna Mountains - principally the Nel-china Limestone (Grantz and others, 1966). Unnamed Jurassic marine sedimentary rocks - Marine clastic rocks of probable Late Jurassic age crop out in the bluffs along the middle reaches of the Cheshnina and Chetaslins Rive stone, siltstone and mudstone, which contain many interbeds of of the Kotsina and resembles it closely in color and degree o Dark greenish-gray siltstone and mudstone predominate in the and Early Cretaceous orogeny that affected all pre-Albia Sparse fossils from outcrops in the Cheshnina River indicate a probable early Late Jurassic (Callovian) age for the unnamed rocks (Grantz and others, 1966). Thus they are coeval with

Mountains (Imlay, 1975) and with the Nizina Mountain Formatio Kotsina Conglomerate - The Kotsina Conglomerate (Rohn, 1900) and also occurs on the north side of the Cheshnina River. I Formation, but its top is nowhere exposed. Most outcrops of the Kotsina are cut by numerous high-angle faults, so its estimated maximum thickness of 500 m is only approximate. The Kotsina consists of bold, craggy outcrops of well-indurated Clasts in the conglomerate are principally dark volcanic rocks of local origin derived from the Nikolai Greenstone and from quadrangle, and only plant scraps have been found elsewhere. The Middle or Late Jurassic age assignment was given by Grant: granodiorite clast was dated at 161 + 6 m.v. and hor at the base of the Berg Creek Formation. Plutons of these ages are widespread in the Wrangell Mountains (MacKevett 1978) and in the Chitina Valley and the northern Chugach Mountains ains (this study). The Kotsina probebly results from local sccelerated uplift and erosion initiating regional Late Jurassic Early Cretaceous orogeny (MacKevett, 1978). Unnamed possibly

correlative rocks from the Talkeetna Mountains (Imlay, 1980) are much thinner and contain only subordinate conglomerate. McCarthy Formation - After several revisions in nomenclature, MacKevett (1963) divided the McCarthy Formation into a lower and an upper member. Only the lower member is present in the Valdez quadrangle, where it forms the westerfmost outcrops of a belt of Upper Triassic and Lower Jurassic marine limestone, shale, and chert that extends nearly the entire length of the southern Wrangell Mountains (MacKevett, 1978). The lower member of the McCarthy gradationally overlies Upper Triassic limestone and is overlain unconformably by the Kotsina Conglomerate or the Berg Creek Formation. The lower member is intruded by numerous felsic to intermediate dikes and sills and by an Upper Jurassic biotite granodiorite stock (Table 1, loc. 2) dated by K-Ar as 144 + 7 m.y. The lower member is incompetent and generally forms subdued outcrops that are characterized by mation precludes reliable estimates of thickness; maximum thickness in the McCarthy quadrangle to the east is on the order of 300 m (MacKevett, 1978), but the formation thins ward, probably because of pre-Kotsina erosion. The lower impure limestone, subordinate fissile shale, and minor chert In many places, the limestone and shale are carbonaceous, and they also contain abundant pelecypods of the genus Monotis and both calcareous and siliceous microfossils. Diagnostic fossils from the lower member of the McCarthy indicate

Chitistone and Nizina Limestones - light- to medium-gray Upper

Triassic carbonate rocks that are so conspicuous along the southern flank of the Wrangell Mountains (MacKevett, 1978)

sxtend in multiple thrust sheets westward into the Valdez quadrangle as far as the Cheshnins River. Upper Triassic

Sedimentary and Volcanic Rocks the Norian stage of the Late Friassic, but they are restricted to the lower part of the member; hence perhaps the upper part of the member may be as young as Early Jurassic (MacKevett,

carbonate rocks slso are present on both sides of the Chiting River near its mouth and on the upland east of Taral. In the McCarthy quadrangle, these carbonate rocks aggregate up to about 1,100 m in thickness, and have been subdivided into a an upper, thinner-bedded sequence - the Nizina Limestone ( 916). Stratigraphic, petrographic, and paleontologic data for the Chitistone and Nizina Limestones in the McCarthy quadrangle are given by Armstrong and others (1970). In the Valdez quadrangle, equivalent carbonste rocks are attenuated greatly, and have thicknesses ranging from only sbout 25 m along Elliott Creek (Moffit and Mertie, 1923) to sbout 250 m east of Long Glacier. In addition, thin-bedded limestone similar to the Nizina Limestone occurs only discontinuously in the sequence. Hence, the two formations have not been subdivided in the Valdez quadrangle. The Upper Triassic csrbonate rocks disconformably overlie the Nikolai Greenstone and grade upward into the lower member of the McCarthy Formation. North of the Cheshnina and the Kotsina Rivers, respectively, the carbonste rocks are overlain directly by the Kotsina Conglomerate and by the Berg Creek Formation. The carbonate rocks consist chiefly of limestone of diverse textural varieties, but include minor dolomite low in the sequence, and nodules and lenses of dark-

No new paleontologic information on the Upper Triassic carbonat rocks has been obtained from the Valdez quadrangle, but the carbonate rocks span most of the Karnian and Norian stages of the Late Triassic in the McCarthy quadrangle (see MacKevett, 1978). Nikolai Greenstone - In the Wrsngell Mountains and near the mouth of the Chitina River, outcrops of altered tholeitic basalt correlative with the Nikolai Greenstone of the McCarth quadrangle occur disconformably beneath Upper Triassic carbonate rocks. Additional outcrops of the Nikolai are present north of Canyon Creek, where the Nikolai overlies unconformably River, where the Nikolai occurs in klippe above rocks as young as an Upper Jurassic biotite granodiorite pluton. South of the Chitina River, the Nikolai has been intruded by an Upper urassic hornblende granodiorite pluton (Table 1, 1oc. 3)

The Nikolai consists of weakly metamorphosed slightly porphyritic tholeiitic basalt that characteristically is amygdaloidal and poorly bedded. Metamorphism of the Nikolai to the prehnitepumpellyite facies is very widespread, but rarely has it masked primary minerals or textures. The dominant phenocrysts, plagioclase (labradorite) and less abundant clinopyroxene, are suspended in fine-grained intergranular groundmasses rich in amounts of iron and titanium oxides and olivine relicts. Amygdules generally are filled with calcite, chlorite, quartz, or epidote, but some contain zeolites, prehnite, or native

In the McCarthy quadrangle, the Nikolai is bracketed stratigraphically by beds that contain diagnostic Middle Triassic (Ladinian) pelecypods beneath and Late Triassic (Karnian) smmonites above (MacKevett, 1978). Its age in the Valdez quadrangle is assumed similarly to be Middle and(or) Late Triassic. The Nikolai is very widespread in southern Alaska and nearby parts of Canada and has been designated to be one of the key units that defines Wrangellia, an allochthonous terrane which extends discontinuously along the Pacific margin of North America at least as far south as Vancouver Island (Jones and others, 1977). Paleomagnetic data obtained from the Nikolai (Hillhouse, 1977) indicate that it formed within 15° of the Upper Triassic equator. Hence Wrangellia is believed to have been transported northward tectonically to its present position. Three K-Ar whole rock ages of the Nikolai Greenstone (Table 1, locs. 8, 9) fall on a 112 + 11 m.y. (late Early Cretaceous) isochron which may in cate the time of accretion of Wrsngellis to North Americs (Silberman and others, 1980)

Skolai Group - diverse Upper Psleozoic volcanic, volcaniclastic and marine sedimentary rocks crop out extensively in the Wrangel Mountains and the Chugach Mountains north of the Tebay fault. In the McCarthy quadrangle, correlative rocks have been subdivided into a dominantly sedimentary Hasen Creek Formation and a dominantly volcanogenic Station Creek Formation (Smith and MacKevett, 1970; MacKevett, 1978). The volcanic and subordinate are strongly deformed and slightly metamorphosed; except for impure limestone and marble equivalent to part of the Hasen Creek (map unit Pm), they have not been subdivided on the map. The Skolai is overlain unconformably by the Nikolai Greenstone; directly on Upper Paleozoic oceanic crust (MacKevett, 1978). Between the Kotsina and Cheshnins Rivers, the Skolai comprises

large klippe above the Kotsins Conglomerate. In the vicinity of the Chitina River, the Skolai is intruded by Upper Permiar hornblende gabbro plutons, one of which (Table 1, loc. 10) is dated by K-Ar at 246 + 12 m.y., and by compositionally varied Upper Jurassic plutons, five of which (Table 1, locs. 2-6) are dated by K-Ar at 144 to 157 m.y. On its southern margin, the Skolai is juxtaposed with amphibolite facies metamorphic rocks faulted, hence its thickness cannot even be estimated. It consists largely of two lithologies: (1) dark, greenish-gray pumpellyite facies mineral assemblages, but retains relict pillows in a few places; snd (2) subordinate light- or mediumgray and buff calcareous rocks, mostly recrystallized to marble, but containing accepts.

No new age-diagnostic fossils have been found in Skolai rocks in the quadrangle, but they correlate with units in the eastern Alaska Range and the Wrangell Mountains that span Middle Pennsylvanian through Early Permisn time and form the regional basement for much of southern Alaska between the Denali and

Itstone and shale. The second lithology comprises map unit

Metamorphic Complex - a diverse and intimately mixed group of low- to medium-grade metamorphic rocks occurs in the north-eastern part of the quadrangle north of the East Fork of the Chetaslina River. Prior to this study, these rocks were desigmylonitic greenschist- and smphibolite-fscies rocks which are cut by post-metamorphic Upper Jurassic and Lower Cretaceous granodiorite plutons and are overlain unconformably by the Wrangell Lava. Dominant lithologies are greenschist and amphibolite, but pelitic and psammitic schist, metschert, and gneiss with pronounced mortar structure are abundant. The foliated phosed Skolai Group, however, they contain no marble but do contain extensive massive to gneissose mafic to intermediate plutonic rocks. In these respects, the foliated rocks are similar to the Triassic and Jurassic "diorite complex" in the K-Ar age of 152 + 6 m.y. on hornblende metagabbro (Table 1, loc. 11) presumably has been reset almost completely by intru-

these metamorphic rocks may have been the Skolai Group, of an upper Paleozoic magmatic src (Richter and Jones, 1973) which subsequently were metamorphosed during one or more of

Granite and Granodiorite - two small discordant stocks of piotite-hornblende granite and granodiorite intrude rocks of the Skolai Group and the Berg Creek Formation north of Canyo Creek. The stocks consist of unfoliated, fine- to mediumas Early Cretaceous but are not deformed and probably are much younger. They may correlate with Eocens intrusive rocks that Spirit Mountain (Table 1, loc. 12) and small seritized tonalite plutons (map unit Tt) west of Chitina (Metz, 1975; Table 1, loc. 13). Hence, the stocks north of Canyon Creek are regarded

Jc | Chitina Valley batholith - Weakly to strongly folisted, Chitina and Kotaina River Valleys, and slong the western flanks as the Middle or Upper Jurassic Kotsins Conglomerate and are but quartz diorite, tonalite, and granodiorite are nearly as abundant. Hornblende generally is the dominant accessory; biotite is present commonly, and in some places is more abund a conspicuous constituent of the large pluton centered in T.2N, R.5E.

K-Ar ages of hornblende from five of the plutons range between 147 + 7 and 157 + 8 m.y. (Table 1, locs. 3-7): K-Ar ages of biotite from two of the plutons are 134 and 144 + 7 m.y. (locs 2, 7). One dated hornblende-biotite mineral pair (loc. 7) is slightly discordant. Hornblende ages are consistently olde than biotite ages in the Chitina Valley batholith, which of hornblende when the rocks are hested during subsequen of Upper Jurassic plutons extends eastward into the McCarth and Bering Clacier quadrangles (MacKevett, 1978), and forms Talkeetna Mountains, but they are in part older than the Chitina Valley batholith and, unlike it, they contain extensive trond jhemite bodies (Csejtey and others, 1978; Hudson, 1979b). Spatial continuity between the Chitina Valley batholith and the Talkeetna batholithic complexes is possible but cannot be

Gabbro and Leucogabbro - Gabbroic rocks are widespread in the Skolai Group as sills, dikes, and discordant plutons; only the larger masses are shown. They consist of medium to coarse-grained, massive to foliated, altered gabbro, leucogabbro, and minor diorite, that is composed predominantly of plagioclase a few places the hornblende can be seen to be replacing earlier

These plutons are coextensive with layered gabbros in the McCarthy quadrangle, which are interlayered with quar monzodiorite or monzonite orthogneiss (MacKevett, 1978). quadrangle, but the plutons are not well studied there. A late Permian K-Ar age of 246 + 12 m.v. (Table 1, loc. 10) on actinolitic amphibole from a large gabbro body south of the be partially reset by intrueion of a nearby Upper Jurassic hornblende granodiorite pluton (Table 1, loc. 7). The gabbroi rocks in the McCarthy quadrangle are interpreted to be part of the Skolai Group (MacKevett, 1978). In the Valdez quadrangle however, the gabbroic rocks have been emplaced at a stration phic level near the base of rocks that are equivalent to the

range in emplacement ages of gabbroic rocks may be indicated.

Wrangell Lava - Andesitic tephra, lava flows, and debris flows resumably emanating from Mt. Wrangell during Late Pleistocene near Chitina, the mouth of Liberty Creek, and along the lower Tonsina River (Yehle and Nichols, 1980). The debris flows extend farther west than the lava flows and in several places are conspicuously altered hydrothermally. In a few places they lie unconformably upon foliated metamorphic rocks. The Wrangell Lava extends undeformed across the buried extension of the Caral fault, as inferred from seromagnetic data. The maximum ages of the superimposed Wrangell Lava outcrops constrain the age of latest displacement on the fault. Unfortunately, these

outcrops are not well dated; they almost certainly are no

Liberty Creek terrane - The most northerly of three faultbounded metamorphic terranas, the Liberty Creek terrane, consists of well-foliated, multiply-deformed greenschist and transitional blueschist facies mafic metavolcanic and metasedimentary rocks (Metz, 1975). It is separated from metamorphic terranes to the south by the Second Lake fault zone, a melange as much as 500 m wide which includes bodies of sheared and serpentinized gabbro, hornblendite, pyroxenite, and garnet pyroxenite. According to Metz (1975), some pyroxenite diaplays cumulate textures. To the east, the Liberty Creek terrane is separated from rocks of domain 1 by the Taral fault. The terrane is intruded by porphyritic andesite plugs and dikes (map unit Tif) that presumably are Eocene in age.

Schistosity is well developed in rocks of the Liberty Creek terrane, although in some places primary sedimentary or volcaniclastic features have been retained. There are no marker strata, however, and there is a complete lack of lateral persistence. Typical mineral assemblages in the rocks include combinations of chlorite, epidote, actinolite, quartz, albite, muscovite, and stilpnomelane, indicating metamorphic conditions in the chlorite zone of the greenschist facies. However, the scattered presence of crossite and a single occurrence of awsonite indicate metamorphic conditions transitional to The Liberty Creek terrane has been presumed to be metamorphosed Skolai Group (MacKevett and Plafker, 1974); this correlation is

made questionable by the lack of marble and by the common intercalation of matasedimentary and metavolcanic lithologies in the Liberty Creek terrane, traits that are not characteristi of the Skolai in the Wrangell Mountains. An alternativa protolith is the McHugh Complex to the west, a tectonic assemblage of interleaved mafic metavolcanic and metasedimentary rocks of prehnite-pumpellyite grade transitional in some places to lower greenschist grade. The age of metamorphism of the Liberty Creek terrane is not known. It may be Jurassic as Metz (1975) has suggested; but a mid-Cretaceous sge seems more likely where some K-Ar metamorphic ages are svailable (see below) Kbc Bernard Creek terrane - A second fault-bounded metamorphic

terrane, south and west of the Liberty Creek terrane, consists predominantly of mylonitic greenschist, and is informally designated to be the Bernard Creek terrane. The greenschist is ntruded by porphyritic hornblende andesite or dacite dikes of map unit Tif. According to Hoffman (1974), relict bedding and olcaniclastic texture can be observed in places. In other places the greenschist is nearly massive, but cataclasis and eomineralization generally are so pervasive that they have obliterated any primary features and have created a megascopic folistion. Cstsclasis and recrystallization appear to have operated in conjunction to reduce grain size, although their relative intensities vary from place to place. In one place a mylonitic fabric may dominate the rocks; nearby rocks may Typical mineral assemblages include combinations of chlorite, epidote, slbite, quartz, muscovite, and stilpnomelane; apparently catsclssis occurred in the chlorite zone of the green-

The Bernard Creek terrane, like the Liberty Creek terrane, has been presumed to be metamorphosed Skolai Group; if the presumption is correct, then the Bernard Creek correlates with the Station Creek Formation. However, the parts of the McHugh Complex that are dominated by mafic volcanic rocks are s likelier protolith.
The age of dynamic metamorphism of the Bernard Creek terrane is believed to be mid-Cretaceous, based on correlation with the Liberty Creek and Haley Creek terranes (see below). Fox Creek terrane - A third fault-bounded metamorphic terrane lies south of the Liberty Creek and Bernard Creek terranes and is designated to be the Fox Creek terrane. It consists of intercalated lower greenschist and transitional blueschist facies metasedimentary and mafic metavolcanic rocks that over broad areas have a cataclastic fabric, but in other areas have reli

schist facies. Pumpellyite is present in many samples, however,

perhaps indicating that metamorphic conditions were transitional with a lower metamorphic grade.

primary sedimentary or volcanic structures such as crossstratification or volcaniclastic texture. The Fox Creek terrsne is intruded by porphyritic hornblende andesite or dacite dikes of map unit Tif and by small sericitized hornblende - biotite tonalite plugs of map unit Tt, one of which (Table 1, loc. 13) has been dated radiometrically as Eocene (see below). The Fox Creek terrane is distinguished from the Bernard Creek terrane by the dominance of dark, very-fine-grained metapelitic rocks where green metavolcanic rocks are present in the Fox Creek terrane, they are indistinguishable from the greenschist of the Bernard Creek terrane.

Typical mineral assemblages include combinations of chlorite, quartz, albite, sericite, epidote, stilpnomelane, and actinolite. Metz (1975) reports two occurences of crossite south of the Second Lake fault zone. Apparently cataclasis and recrystallization took place concurrently; their relative influence on fabric varies markedly from one place to another. The age of the Fox Creek terrane is not known. It probably shares a common metamorphic history with the Liberty Creek and Bernard Creek terranes, however, and likewise may represent rocks of the McHugh Complex that were metamorphosed in the mid-

Haley Creek terrane - Between the O'Brien Creek, Taral, and Tebay faults on the north and east and the Spirit Mountain fault on the south is the Haley Creek terrane, which consists of metamorphosed plutonic and sedimentary rocks. The Haley Creek terrane is complexly deformed and tectonically mixed. Unpublished detailed mapping by W. K. Wallace (written commun. 1980) near the headwaters of the Uranatins River and Haley Creek indicates that the metaplutonic rocks are most abundant ized distribution is shown by the map pattern of unit Kag. Th metsplutonic rocks are compositionally diverse and weakly to strongly foliated. Although diorite and quartz diorite are the most abundant lithologies, the metaplutonic rocks range djhemite is especially conspicuous in many places immediately north of the Spirit Mountain fault, and it has been subjected to more intenss cataclasis than many other rocks in the rane. Amphibolite is widespread within the metaplutonic rocks; locally it is gradational with the metaplutonic rocks and may have been reconstituted from early mafic phases of the plutonism terrane, where marble, metapelite, and metapaammite are structurally mixed with subordinate metaplutonic rocks.

marble layers can be traced for more than several kilometers, the layers vary greatly in thickness, terminate abruptly in places, and generally are thoroughly folded. Small, isolated bodies of marble mark numerous unmapped faults within the Rocks of the Haley Creek terrane record two major metamorphic events: an earlier epidote-amphibolite facies event, which is not represented in the Liberty Creek, Bernard Creek, and Fox Creek terranes to the north, and a later mylonitic green-schist facies event, which affected all four terranes and, in the Haley Creek terrane, obscured textures or assemblages from the earlier event. The earlier epidote-amphibolite facie metamorphic event is not preserved well in most rocks of the mineral assemblages - particularly epidote, almandine, and metamorphic hornblende. However, most rocks have a pervasive mylonitic schistosity and consist of various combinations of albite, quartz, chlorite, muscovite, and biotite, with lesser metamorphic event is best recorded in the metasedimentary rocks, which are thoroughly sheared and recrystallized to biotite-grade assemblages. In addition, all rocks of the Haley Creek terrane are cut by veins of quartz, csrbonate

Four K-Ar ages of hornblende from metaplutonic rocks of the Haley Creek terrane (map unit Kag) (Table 1, locs. 14, 16-18) range from 148 m.y. (Late Jurassic) to 122 m.y. (Early Cretaceous) One K-Ar age on muscovite from metamorphosed trond hemite (loc. 19) is 133 + 4 m.y. Two K-Ar ages on biotite and muscovite from the enclosing schistose rocks (map unit Khc) (locs. 15, 0) are 123 and 110 m.y. respectively. The generally older hornblende ages and younger mica ages reflect the greater argo retention of hornblende. Scatter among the ages probably results from variation in thermal conditions in the terrane, the ages of muscovite between localities 19 and 20 and in tages of hornblende between localities 16 and 17 may be the result of grain size variation. The older ages from both sets of minerals are from the coarser grained concentrates. Argon retention in mica has been shown previously to be a function of inctive banded schist (loc. 21) gave an anomalously young K-Ar age of 50.0 + 1.0 msy., an age approximately the same as Eocene hypabyssal plutons that intrude the terrane. No pluton was identified at the sample site, but the age is reproducible. The polymetamorphic character of the Haley Creek terrsne makes determination of its correlation equivocal. The terrane has been mapped previously as metamorphosed Skolai Group (MacKevett and Plafker, 1974), in which case the metaplutonic rocks of map unit Kag are correlative with the Chitins Valley batholith. However, the Haley Creek terrane does not grade northward into less metamorphosed rocks more typical of the Skolai, as suggested by MacKevett (1978), but rather is juxtsposed against the Skolai and the Chitina Valley batholith along the high-angle Tebay fault. Inasmuch as the Heley Creek terrane is juxtaposed

Altered biotite and hornblende tonalite - small discordant stocks of tonalite occur on the uplands west of Chitins and near the headwaters of O'Brien Creek. They intrude foliate Creek terranes, but are not folisted themselves. They may b elated to porphyritic hornblende andesite and dacite dikes medium-grained sericitized tonalite with minor quartz diorite and granodiorite. Either biotite or hornblende may be the dominant mafic accessory in particular parts of the stocks; in most samples, muscovite has replaced biotite or has formed The small pluton west of Chitina (Table 1, loc. 13) has three

against dissimilar rocks on opposite sides of the Taral fault, the terrane may be allochthonous and unrelated to either the Skolai Group or the Chitina Valley batholith.

Eccene K-Ar ages: (1) hornblende from the periphery of the pluton and (2) from its hornfelsed aureole are 46.6 + 1.4 and 44.4 + 1.3 m.y. respectively (Metz, 1975); and (3) muscovite Gold and sulfide minerals (chiefly pyrite, arsenopyrite, sphal-srite, and galena) occur as disseminations within the pluton Hornblende Gabbro and Leucogabbro - Layered gabbro and leucogabbro are associated spatially with ultramafic rocks near the Bernard Mountain, Dust Creek, and Scarp ultramafic bodies (see below), and at s small outcrop along the Tonsina River 8 km west of Lower Tonsina. Gabbro is interlayered with clinopyro enite near the west edge of the Scarp body, where it contains lenses of clinopyroxenite; elsewhere contacts between gabbro and ultramafic rocks are very poorly exposed or covered. The layered gabbro consists dominantly of hornblende gabbro; hornblende-augits gabbro is common, however, with the hornblende

replacing or molded upon the augite; and layers and lenses of hornblendite occur at saveral places. Hoffman (1974) has described a lens of epidote- and garnet-rich mafic rocks on the east side of the Bernard Mountain ultramafic body, which we have correlated with this unit. Compositional layering of the

gabbroic rocks is conspicuous in many places, and consists of

alternating layers rich in hornblende or pyroxene and in plagioclase. Granulation of the gabbro and associated ultramafic rocks is severe in a few places Although the layered fabric and mineralogy of the gabbroic rocks led Ragan and Grybeck (1966) and Hoffman (1974) to describe them as hornblende-pyroxene granulite, amphibolite, and quartz diorite gneiss, the basic character of the rocks is plutonic. They may be related to the layered mafic plutonic belt in domain that extends more than 100 km westward from near Tonsina (map unit Jmp). Alternatively, the gabbroic and the ultramafic rocks may be a large tectonic fragment bounded entirely by faults and similar to the roughly circular tectonic inclusion in the McHugh Complex between the Nelchina and Tazlina Glaciers (domain 4: map units Jlg, Ja, Jag). K-Ar age determinations that might help indicate the likelier of these two alternatives are equivocal. Three hornblends ages from the gabbroic rocks exhibit wide scatter: 419 ± 21 m·y. (Table 1, loc. 22), 188 ± 8 m·y. (loc. 23) and 171 ± 5 m·y. (loc. 24, Hoffman, 1974). The hornblende ages from localities 23 and 24 are only slightly older than ages from the layered mafic plutonic belt. The third age of 419 + 21 m.y. is difficult to explain. The horn-

blende from this sample is extremely low in potassium (fable 1); it may contain excess radiogenic argon, causing an anomalously old apparent age. Initial argon data from the three samples de not plot on s single line, so an isochron age (Shafiquilah and Damon, 1974) cannot be calculated. Thus, the age of the gabbro and leucogabbro may be Early Jurassic or it may be older, perhaps considerably older.

Ultramafic rocks - Dunite, harzburgitic dunite, wehrlite, websterite, and clinopyroxenite crop out in s discontinuous belt more than 25 km long that extends from Bernard Mountain on he southwest to the Tonsina River on the northesst. Thes rocks, which comprise the Tonsina ultramafic complex, are in ault contact with the Liberty Creek and Bernard Creek terranes, Strongly sheared serpentinite, clinopyroxenite, and amphibolite occur in discontinuous bodies slong the Second Lake fault and another unnamed fault one kilometer to the north (Metz, 1975). Several isolated pods of serpentinized ultramafic rocks occur in intensely faulted zones of the Haley Creek terrane east of the Copper River. In the Tonsina ultramafic complex, dunite is the predominant lithology; the proportions of subordinant pyroxenite and peridotite vary from place to place. At Berner Mountain, dunite and harzburgitic dunite comprise more than 99 of the outcrop, with clinopyroxenite forming only about 1% (Hoffman, 1974). The ultramafic rocks on both sides of Dust Creek also are predominantly dunite; however, perhaps as much as 20% of the outcrop there consists of websterite and linopyroxenite. To the northeast at triangulation station "Scarp", ultramafic rocks consist of approximately 70% dunite, 10% wehrlite, and 20% webaterite and clinopyroxenite. Chromite is not abundant in the Tonsina ultramafic complex; it is widely inated in most dunite, but generally is not concentrated or podiform. Hoffman (1974) cites up to 5% disseminated chromite in dunite from Bernard Mountain. Peridotite, a minor component of the complex, contains up to 2% disseminated chromite. The Tonsina ultramafic complex apparently is folded, but is not thoroughly sheared and serpentinized. The absence of intense deformation and the association of layered gabbro and hornblendite may indicate original zoning in the complex prior to its tectonic emplacement within greenschist facies metamorphic rocks. The discontinuous ultramafic bodies along the Second serpentinized; remnants of dunite, peridotite, and pyroxenite are preserved within them, which may indicate that, although these bodies were intensely dismembered during emplacement, thay were derived from an ultramafic complex of variable litho-The age of the Tonsina ultramafic complex is uncertain. Insamuch as it apparently is linked genetically to the layered gabbro and leucogabbro, its age also may be Early Jurissic or

Analogues of the discontinuous ultramafic bodies are scattered widely north of the Border Ranges fault in adjoining quadrangles DOMAIN 3 Sedimentary and volcanic rocks QTw Wrsngell Lava - see description for Domain 2.

older. The ultramafic complex is correlative with the Wolverin (Clark, 1972a) and Eklutna (Rose, 1966) complexes to the west.

Matanuska Formation - Upper Lower and Upper Cretaceous marine clastic rocks crop out in the northwestern corner of the Valdez quadrangle and extend westward into the Nelchina srea, where hey have been mapped as the Matamuska Formation (Grantz, 1961). Correlative rocks are widespread to the east in the southern Wrangell Mountains, where they consist of the Kennicott, Moonshine Creek, Schulze, Chititu, and MacColl Ridge Formations (Jones and MacKevett, 1969). The Matamuska has been subdivided informally into a lower and an upper part, which presumably are separated by an unconformity similar relations in the Nelchina area (Grantz, 1964, 1965). In the Valdez quadrangle, the top of the formation is not exposed; the base is an angular unconformity on the Lower Jurassic Upper part - A very thick sequence of marine siltstone, claystone,

Upper part - A very thick sequence or marine siltstone, claystone, and sandstone is interbedded with lenticular and channelized deposits of sandstone and conglowerate in the upper part of the Matanuska Formation. The aggregate thickness of these rocks is several thousand meters in the Nelchina area, where they have been studied in much greater detail and have been subdivided into several units (Grantz, 1961, 1965). The contact between the upper and lower parts of the Matansuka is not well exposed it is presumed to be an unconformity, as in the Nelchina area. fringes of s deep-sea fan. Thinly interbedded siltstone, claystone, and sandstone, which predominate, represent deposition in interchannel areas; whereas thick beds and lenses of sandstone and conglomerate represent deposition in distributary channels and lobes that fed sediment to the distal reaches of the fan. The sources for the sediment must have been only a few tens of kilometers distant, for coeval parallic facies of the Matanuska Formation occur in the eastern Talkeetna Mountains (Grantz and Jones, 1960). Preliminary paleocurrent measurements indicate that much of the upper part of the formation in the Valdez quadrangle was derived from nearby sources to the south. Although no age-diagnostic fossils have been collected from the Matanuska Formation during this study, deposition of the upper part of the formation in nearby areas is known to span most of the ages of the Late Cretaceous from mid-Coniacian to Maestrich

Kml Lower part - Marine siltatone, shale, sandstone, and pebbly sandstone are interbedded with subordinate siliceous miniferal shale and fine-grained zeolitized sandstone in the of these rocks in the adjacent Nelchina area, where they have been subdivided into several map units, is more than 800 m.
The lower part of the Matamuska Formation is a transgressive marine sequence, characterized by a basal pebbly sandstone, i part glauconitic, that was deposited in shallow, agitated water in angular unconformity upon volcanogenic strata of the Talkeetna Formation. The basal beds grade upward or are disc No age-diagnostic fossils were collected from the lower part the Matanuska during this study. In the southeast part of the Nelchina area the bass beds are late early Albian (Grantz, 1965), and the overlying lower part of the Matsmuska spans the Cenomanian, Turonian, and early Coniacian ages of the Late

Talkeetna Formation - Marine and non-marine andesitic and basaltic tuff, tuff breccia, flows, and volcanogenic sedimentary rocks which contain mollusks and brachiopods comprise the fountains. Small, isolated bodies of light- to dark-gray unfossiliferous saccharoidal limestone near the original Edgerton highway between Willow Creek and Kenney Lake that were mapped as bedrock by Nichols and Yehle (1969) are of unknown affinity to the west, they are designated as limestone lenses within the formation (map unit Jl). However, limestone has been recognized nowhere else within the Talkeetna in the Valdez quadrar large bodies of marble do occur in the formation in the hear waters of the Kings River, more than 150 km to the west (Cae and others, 1978), and limestone beds are intercalated with The Talkeetna is extensively faulted, and, in places, it is folded, altered, iron-stained, or hornfelsed. Its thickness its thickness exceeds 2,000 m and may exceed 3,000 m. The formation is intruded by compositionally and texturally diverse stocks of granodiorite and granite (map units Jgd and Jgr).

The Talkeetna Formation is widespread in southern Alaska, and

extends from Pusie Bay on the Alasks Peninsula (Burk, 1965; Detterman and Hartsock, 1966) to the vicinity of the Copper

River. Its age is well documented as Early Jurassic, and i forms the oldest exposed part of the Peninsular tectonostratigrsphi terrane (Jones and Silberling, 1979). The Talkeetna contrasts markedly with coeval rocks in the Wrangell Mountains, which are not volcanogenic; hence the Peninaular and Wrangellia terranes probably were not juxtaposed until Middle Jurassic. Jgr Biotite - epidote granite - Irregularly-shaped small stocks of pink-weathering medium-grained granite intrude the Talkeetna Formation between Tazlina and Hudson Lakes. The rocks are haracterized by graphic intergrowths of altered plagioclase plagioclase cores in many specimens. Green biotite and granula to very-coarse-grained epidote are constant accessories. The biotite generally is chloritized and, in at least one specimen eastern contact of a widespread Middle Jurassic granodiorite pluton in the Talkeetna Mountains. In addition, the granite

appears to be gradational texturally and composit

(map unit Jgd) that resemble the Middle Jurssic pluton he southeastern Talkeetna Mountains. The granite stocks may be the youngest phase of the Middle Jurassic magmatic event, a Jgd Biotite - hornblende granodiorite - At least two stocks of between Tazlina and St. Anne Lakes, and a smaller pluton intrudes the mafic plutonic complex (map unit Jmp) east of Barnett reek. Slightly altered plagioclase, quartz, and lesser k feldspar form a characteristic medium— to fine-grained hypidio-morphicgranular texture. Green biotite is a constant accessory hornblende and epidote are less abundant and are not present in 11 samples; biotite and hornblende generally are chloritized. No radiometric ages are available for the granodiorite stocks in the Valdez quadrangle. The stocks probably are the southern-most apophyses of much larger batholithic complexes of similar composition in the southeastern Talkeetna Mountains, such as

ite-hornblende granodiorite stocks in the Valdez quadrangl

the Kosina pluton (Grantz and others, 1963). Granodiorite of he Kosina pluton is dominantly of Middle Jurassic age (Csejtsy Jmp Msfic plutonic complex - A mafic plutonic belt at least 120 km long and as much as 10 km wide extends from east to west across two-thirds of the quadrangle and continues westward a least as far as the Matanuska Glacier in the Anchorage quadrangle. The plutonic belt consists dominantly of layered hornblende-pyroxene gabbro and leucogabbro, with minor ultra-mafic, dioritic, and tonalitic rocks. The layered mafic comple coincides with very large positive seromagnetic and gravity anomalies (Andreason and others, 1964; Barnes, 1977; U.S. Geological Survey, 1979), permitting extrapolation of its position eastward as a continuous belt beneath surficial deposits of the Copper River Basin to at least as far east

> The southern margin of the layered mafic complex is a major fault zone, as indicated by extensive serpentinization and inclusion of exotic blocks of diverse lithologies within the mplex near the fault is severe; in many places the complex is thoroughly sheared and includes boudins of country rock.
> Mylonitic layering also is conspicuous along a major east-west
> fault within the complex between Nelchina Glacier and Tazlina Lake that contains tectonic lenses of serpentinite. The northern margin of the layered mafic complex generally is not well exposed, but it is apparently a fault zone. Two gabbro stocks intrude the Lower Jurassic Talkeetna Formation north of the fault zone, but it is not certain that they are related to the main mafic plutonic complex to the south. Compositional layering is conspicuous in the gabbro in many places. The layers consist predominantly of calcic plagioclase alternating with pyroxene and hornblende that replaced or surrounded pyroxene. Magnetite and quartz generally are present and sverage about 2% and 3%, respectively. K-feldspar and biotite are present in samples of more leucocratic phases, and pyrite is present in many samples of more melanocratic Hudson (1981) has defined a northern Chugach Mountains plutonic

belt of tonalitic and gabbroic rocks that extends eastward from near Palmer in the Anchorsge quadrangle to the vicinity of Tonsina. The Wolverine Complex of layered gabbro and ultramafic rocks is associated spatially with the western part of the suite; the mafic plutonic complex forms the

eastern part. This belt may be an extension of the Lower

Jurassic and Upper Triassic(?) Afognak and unnamed plutons that crop out on the west coasts of the Kodiak archipelago,

the Barren Islands, and the Kenai Peninsula, and have single

1979a, b). Alternatively, the mafic plutonic complex in the northern Chugach Mountains may be a separate, younger belt.

mineral K-Ar ages ranging from 184 to 193 m.y. (Hudson,

that are not studied thoroughly. The rocks are composed mostly of chlorite, quartz, albite, and muscovite, an assemblage which indicates lower greenschist facies metsmorphic conditions. The contact to the north with less conspicuously foliated metasedimentary rocks of the Valdez Group (map unit Kvs) is gradational

Four preliminary K-Ar ages on low-potassium hornblande and one on chloritized biotite (Table 1, locs. 25-28) range between 153 and 171 m.y. (Middle and Late Jurassic). The age range may be real inasmuch as the layered complex has a spectrum of rock types. One dated hornblende-biotite pair is concordant, despite alteration of the biotite - which suggests that the alteration is deuteric. The concordance also indicates that the ages probably have not been reset by subsequent metamorphic heating. Apparently, the mafic complex is approximataly contemporaneous with Middle and Late Jurassic magmatism in the southeastern Talkeetna Mountains.

Ultramafic rocks - One body of serpentinized pyroxenite(?) has been mapped within the mafic plutonic complex near the headwaters of Bottley Creek. Many other bodies, generally localized in strongly sheared zones, occur within the complex but are too small to distinguish on the map.

Sedimentary and Volcanic Rocks Orca Group - Paleocens and Eocene(?) flyschoid sedimentary rocks and tholeiitic volcanic rocks of the Orca Group crop out on the west side of Valdez Arm in the southwestern corner of the map. They are separated from older rocks of similar ithology - the Valdez Group - to the north by the Conte fault system of northward-dipping reverse faults. Rocks of the Orca Group are strongly deformed and are metamorphosed to the prehnite-pumpellyite facies. Although no fossils have been collected from sedimentary rocks of the Orca Group in the Valde: quadrangle, outcrops there are co-extensive with Orca rocks to the south and east that have yielded meager microfaunal and megafaunal collections of Paleocene and Eocene(?) age (Winkles 1976a). The Orca Group also extends westward through the Anchorage quadrangle to western Prince William Sound and the Kenai Peninsula (Tysdal and Case, 1979), and is correlative with the Ghost Rocks Formation of Kodiak Island (Plafker, Tov Volcanic rocks, undivided - Tholeititic pillow basalt, pillow breccia, and minor squagene tuff comprise the volcanic part breccia, and minor aquagene tuff comprise the volcanic part of the Orca Group. The pillows are most conspicuous on the west side of the entrance to Sawmill Bay, but are prominent at nearly all outcrops. The pillows generally are packed tightly, and they may be either bulbous or elongated and are up to 2 m across.

Most pillow rinds have polygonal cracks and are weakly amygdaloidal but the cores of pillows are dense and aphyric. Interstices

green or red chert is present locally. In several places, the volcanic rocks are mantled by pillow breccia which contains mostly angular volcanic clasts but includes rounded non-volcani clasts and grades into conglomerate. These rocks have been distinguished on the map as a separate unit (Toc). Thin sequen ces of dark-grey argillite and siltstone are interbedded with the volcanic rocks, and in places the argillite has been com-pressed between pillows; it is apparent that in these places the pillow basalt was extruded upon unconsolidated mud Volcanic rocks of the Orca Group consist exclusively of oceanic tholeiite (Winkler, 1976b; Tysdal and others, 1977) which are conformable with enclosing flyschoid sedimentary rocks. On a regional scale the tholeiites are lenticular, which may indicate that they were erupted from several centers. Existing paleontologic dating is inadequate to define whether volcanism in the centers was synchronous. Sedimantary rocks, undivided - Marine argillite, siltstone, sandstone, and conglomerate comprise the sedimentary part of the Orca Group west of Valdez Arm. Conglomeratic rocks have been mapped separately (Toc). The sedimentary rocks are very

thick and consist of well-bedded, repetitive finer-grained and coarser-grained strata; primary sedimentary features that are diagnostic of deposition by sediment-gravity flow processes (primarily turbidity currents) are widespread in the rocks.
Argillite and siltstone are more abundant than coarser-grained and southwest (Tysdal and Case, 1979). Distinctive associations of turbidite facies in sedimentary rocks of the Orca Group indicate that they were deposited on a complex, westward-sloping submarine fan (Winkler, 1976a). The dominance of finer-grained facies west of Valdez Arm indicates that most deposition occurred from the upper levels of sedimentgravity flows which overtopped major distributary channels on

According to the criteria of Dickinson and Suczek (1979), provenance for the sedimentary rocks of the Orca Group must have been a dissected magmatic arc. A possible source is the plutonic and high-grade metamorphic complex of the Coast Mountains of British Columbia and southeastern Alaska. Hollister (1979) has demonstrated erosion of 10 to 20 km from the Coast fountains during the early Tertiary. Presumably the resulting sediment was deposited initially along the continental margin as submarine fans, but was subsequently displaced northwestway by dextral transform faulting along the margin of the North

Toc Conglomeratic sedimentary rocks - Very poorly bedded conglomeratic sandstone and argillite mantle the tops of volcanic sequences in several places west of Valdez Arm. The conglomeratic rocks are very poorly sorted: clasts vary in size from granules to boulders and are supported by matrix. The basal parts of conglomeratic beds frequently contain angular to partly rounded clasts of basalt identical to the substrate, which probably are rounded non-volcanic clasts. Gradationally upward, the conglomeratic strata contain fewer volcanic clasts, but al In this respect, the conglomeratic rocks are different from most conglomerate in the Orca Group, which contains diverse clasts of extrabasinal lithologies (Winkler and Tysdal, 1977) The conglomeratic rocks are similar, however, to fossili Cordova quadrangle, which is interstratified with pillow basalt and flysch (Plafker and MacNeil, 1966).

TKm Melange - Between the Nelchina Glacier and Tazlina Lake, the truncated by a zone of melange up to 4 km wide which narrows eastward and delimits the Border Ranges fault. The melange consists of extensive serpentinized ultramafic rocks including dike-like bodies of rodingite, as well as blocks of layered gabbro, crossite schist, pillow basalt, marble, chert of probable Late Triassic or Early Jurassic age (Table 2, loc. 14), and diverse metamorphosed and virtually unmetamorphosed sedimentary rocks, including conglomerate that resembles lithologies within the Chickaloon Formation of Paleocene age in the Anchorage quadrangle. The melange is intruded by post-tectonic hypabyssa. tocks of porphyritic hornblende andesite and dacite (map unit component of the melange is ultramafic rocks, which chiefly are serpentinite, but which include incompletely serpentinized n some of the ultramafic rocks. To the south, the melange is juxtaposed against the McHugh Complex (see below) along a steeply north-dipping or vertical series of closely-space faults. The melange is distinguished from the McHugh Complex by its more thorough dismemberment, by its abundant ultramafic rocks, and by its much greater diversity of exotic blocks. In fact, the melange apparently contains blocks of both of its neighbors, the Tonsina mafic plutonic complex and the McHugh Complex. Only one block of McHugh Complex, however, is large

developed in the melange in many places. It consists of blocks of a wide range in size, with their maximum dimensions crudely alined with the prevailing steep cataclastic foliation. age of development of the melange must be bracketed between the ages of the youngest blocks that it includes and the older these ages can only be inferred presently. The hypabyssaintrusions may be as old as Eocene (Grantz, 1960), but the probable Late Jurassic age and of the McHugh Complex with Jpper or Lower Jurassic radiolarian cherts have been identified Valdez Group - Upper Cretaceous flyschoid sedimentary rocks and tholeiitic volcanic rocks crop out in a belt up to 50 km wide

fault. Rocks of the Valdez Group are strongly deformed and in

primary sedimentary structures are preserved in many of the greenschist facies is typical, and is especially well displayed and the entire sequence of Valdez Group rocks increases in grade quadrangles that has been described by Hudson and others (1979). The Valdez Group in the quadrangle is coextensive with rocks to the west that have yielded scant Maestrichtian (Late Cretaceous) pelecypods (Jones and Clark, 1973). Despite the width of the outcrop belt, no older fossils have been recovered; hence, after it was deformed against and accreted to the continental margin. Metamorphism apparently overlapped anatectic plutonism in the Sanak-Baranof belt (Hudson and others, 1979). Numerous elsic to intermediate dikes, sills, and plugs (map unit Ti Group throughout the full width of its outcrop belt in the quadrangle. Muscovite from a small post-metamorphic muscovite granite plug on the east side of the Columbia Glacier (Table 1, loc. 29) has been dated by K-Ar as 51.6 ± 1.5 m.y.

Matavolcanic rocks, undivided - Mafic metatuff and minor massive or weakly-foliated greenstone with rarely preserved vague pillow shapes comprise the volcanic part of the Valdez Group. These rocks are not widespread in the Valdez quadrangle, but extend abundant (Winkler and Plafker, 1981). Although the metavolcanic persist for more than twenty kilometers along strike, and are conspicuous in a broad east-west zone from east of the Copper Most metavolcanic rocks are schistose and consist of aggregates of actinolite, epidote, chlorite, carbonate, and quartz. Stilpnomelane is present locally, and veins rich in pumpellyite

occur in a few places. Horizons of metavolcanic rocks are the loci of intense deformation. Even where surrounding metaclastic are nearly completely recrystallized, with only small areas of relict volcanic texture. Areas within or on the margins of metavolcanic rocks often contain either disseminations or concentrations of pyrite, pyrrhotite, chalcopyrite, cubanite nd sphalerite, most notably at the Midas Mine in Solomon Gulch. but also southeast of Sulphide Gulch, west of Wortmanns Glacier, Metasedimentary rocks, undivided - Weakly to strongly foliated marine argillite, siltatone, sandstone, and conglomeratic sandstone comprise the metasedimentary part of the Valdez Group. Because of structural complexity and nondescript lithologies,

the aggregate thickness of the metasedimentary rocks is not known, but at least several thousand meters of repetitive finer grained and coarser-grained strata are present. Pelitic rocks are most abundant immediately south of the Tazlina fault; metasandstone predominates along the crest of the Chugach Mountains, where strata as thick as 50 m have been observed Such thicknesses of sandstone must represent the amalgamation Provenance for the metasedimentary rocks must have been predominantly a supracrustal volcanic terrane (Mitchell, 1980; Zuffa and others, 1980), which also is true for the correlative

Kodiak and Shumagin Formations to the southwest. Inasmuch as the Valdez Group may have been deposited far to the south and have been transported tectonically northward to be accrated to the Alaska continental margin (Gromme and Hillhouse, 1980), the identity of that source terrane is unknown. Phyllite and schist - Low-grade metsmorphosed pelitic rocks crop out in the extreme southeastern corner of the quadrangle, where they are exposed on the north flank of a regional metamorphic complex that extends southeastward into the adjacent Cordovs and Bering Clacier quadrangles (Hudson and others, 1979). The pelitic rocks consist of homogeneous phyllite and schist

and is poorly exposed; its location in brush-covered lowlands along the Bremmer River is placed arbitrarily. Biotite is present in most samples from the south edge of the quadrangle and minute crystals of epidote and garnet are present in a few samples, indicating attainment there of at least highe greenschist facies conditions and a gradual increase in

McHugh Complex - A pervasively deformed assemblage of diverse lithologies between the Tazlina and Border Ranges faults correlates with the McHugh Complex of the Anchorage area (Clark, 1972b, 1973), the Seldovia Bay Complex of the southern Kenai Peninsula (Cowan and Boss, 1978), the Uyak Complex of the Kodiak Island region (Connelly, 1978), and the revised Kelp Bay Group of Chichagof Island in southeastern Alaska (Decker, 1980). In the Valdez quadrangle, broad, poorly-defined zones of intense shearing in the McHugh lack any stratal continuity and in most places are marked by tectonic inclusions (many ar of mappable size) of marble (map unit M), thoroughly altered and sheered quartz diorite, diorite, and gabbro (GG), or green schist and transitional blueschist (Jgb), which are alined in a matrix of argillite or phyllite. Elongated bodies of marble are the most prominent inclusions. The Klutina and Iceberg faults delineate two such zones; numerous other zones are present but are not mapped separately. These zones are trumelange, and they bound large tracts of less chaotic McHugh Complex with some stratal continuity that are better characterized as broken formation. This less chaotic McHugh corre ponds conceptually to the collage facies of the Kelp Bay Group (Decker, 1980). The large tracts are up to 10 km or more in strike length and consist mostly of chloritic argillit with wispy lenses of green tuff, thinly bedded very siliceous argillite and argillaceous chert, massive and pillowed green stone, and lesser light-tan and maroon chert and wacke sand-

The McHugh Complex has been interpreted (Clark, 1973; Moore plutonic and metamorphic rocks, including blueschist) in a of assemblage of these disparate components is somewhat from the McHugh Complex in the Valdez quadrangle (Table 2) range in age from Triassic to mid-Cretaceous (C. D. Blome, D. . Jones, and B. L. Murchey, written commun., 1981 ians from maroon chert a few meters above the Tazlina fault yet reported from the McHugh. Hence, as Connelly (1978) h suggested, the likeliest age of emplacement for the McHuch i Late Cretaceous. In the Valdez quadrangle, at least three discrete belts of McHugh Complex are present: (1) a northerly aults, which has yielded exclusively radiolarians of Jurassic and Cretaceous age; and (3) a southerly belt, between the Iceberg and Tazlina faults, which has yielded radiolaria as

domain 4 have two distinct modes of occurrence: (1) as blocks enclosed by McHugh Complex. Schistose blocks along the Klutins fault are as much as 2 km in length and as much as 250 m thick, into northern and southern segments of about equal width. Fou blocks of schist occur in the southern segment of McHugh. T belt of schist is bounded on its upper and lower contacts by melange that ranges in thickness from only a few meters to more than a kilometer and contains conspicuous blocks of marble suspended in an argillite to phyllite metrix. calcareous rocks. In most blueschist, the typical minera suite of crossite, epidote, and calcits, and the sporadic presence of garnet, indicates relatively high temperatures and pressures which are transitional with greenschist metamorphic onditions. Affinities with the greenschist facies also are actinolite, stilpnomelane, and albite. In some blueschist however, glaucophanic crossite and lawsonite coexist with epidote and calcite, indicating relatively lower temperature The greenschist and associated blueschist are similar, in mineralogy and lithologic associations, to rocks on Kodlak and Afognak Islands and near Seldovia (Carden and others, 1977),

inclusion approximately 15 by 10 km that contains layered quart gabbro (map unit Jlg), amphibolite and orthogneiss (Jag), and thoroughly dismembered amphibolite-facies metamorphic rocks that contain numerous lenses of ultramafic rocks (Ja). Analogou rocks are not known to be present anywhere else within the McHugh Complex. The tectonic inclusion apparently is rootless, inasmuch as contacts dip inward everywhere around its periphery. The amphibolite-facies rocks consist of nondescript, weakly foliated to non-foliated granular rocks of uncertain protolith matamorphosed feldspathic and quartzose sedimentary rocks. They are laced with numerous dike-like bodies of amphibolite The amphibolite-facies rocks are structurally complex, and contain many lenses of incompletely serpentinized ultramaf and gabbroic rocks, especially on the west side of Klanelnee-chena Creek. The ultramafic rocks chiefly are clinopyroxenit and olivine clinopyroxenite. All the rocks have been extensively retrograded: original plagioclase-hornb garnet assemblages have been raplaced partially or completel

very mafic amphibolite to hornblende-biotite digritic and quar loc. 39) has been dated by K-Ar at 267 + 8 m.y. (mid-Permian), which may approximate the time of metamorphism in both the metaplutonic rocks and their apparent roof rocks (map unit

facies metamorphic rocks are not well exposed and have been modified during prehnite-pumpellyite facies metamorphism o both units. Contacts are presumed to be intrusive, inaamuch the quartz gabbro retains hypidiomorphic-granular texture, and andesine) and quartz give the rock its prominent banded appearance. The body is similar to the mafic plutonic complex of domain 3 (map unit Jmp), except that it consistently contain anhedral interstitial quartz, and hornblende is only a minor accessory. The body is relatively undeformed and dips quite A K-Ar age of 185 + 19 m.y. (Esrly Jurassic) has been measured on pyroxene from the body (Table 1, loc. 40). This age, although imprecise due to very low potsssium content of the pyroxene and a high content of atmospheric argon, is similar to the average of four K-Ar ages from hornblende diorite of the Afognak pluton (188 + 5 m.y., Carden and others, 1977), one age from quartz diorite on the Barren Islands (187 + 14 m.y., Cowan and Boss, 1978), and reputed ages from small dioritic to gabbroic plutons near Seldovia. These plutons of the Kodiak-Kenai balt (Hudson, 1979), however, apparently intruded Upper Triassic through Lower Jurassic forearc deposits, rather than e-facies metsmorphic rocks as does the layered quarta

Rocks of the McHugh contain characteristic prehnite-pumpellyit facies associations of metamorphic minerals. Prehnite is mos-common in the metasedimentary rocks; pumpellyite and prehnite ars present in most metavolcanic rocks. Dikes and small plugs of felsic hypabyssal rocks (map unit Tif) are present at scatlithologies (gabbro and greenstone upon which chert, argillite, and wacks were deposited) and offscraped fragments of continental margin or older subduction assemblages (marble, wacke, diverse subduction zone. During underthrusting, indurated rocks were broken into fragments of all sizes and were enclosed in a less competent matrix of argillaceous or siliceous rocks. The age equivocal, but the style of deformation indicates that the age of the youngest rock is most significant. Previously reported ages of microfossils recovered from the McHugh range from late Paleozoic (Pennsylvanian?) to Early Cretaceous (Clark, 1973; Karl and others, 1979). Twenty-one radiolarian collections the only radiolarian collections of Triassic age occur (Table 2 locs. 15-17); (2) a medial belt between the Klutina and Iceberg

There is no known overlap between the paleontologic ages of the McHugh Complex and the Valdez Group. Structurally, the Valdez has been emplaced beneath the McHugh, and therefore it age of accretion is somewhat younger. Moore and Connelly (1977) have suggested that perhaps the McHugh is a more deeply subducted of the same Late Cretaceous accretionary event. However, the typical relatively lower-grade prehnite-pumphallyite facies metamorphism of the McHugh Complex and greenschist facies matamorphism of the Valdez Group are the opposite of what might e expected for the supposition of Moore and Connelly (1977)

METAMORPHIC ROCKS Jgb Greenschist and transitional blueschist - Schistose rocks in belt 40 km long and as much as 4 km wide, which extends northeastward from near Nelchina Glacier to Klutina Lake and is and are associated with elongate bodies of marble. The discrete belt of schist divides the McHugh Complex west of Klutina Lake schist, carbonaceous schist (particularly near contacts with melange), highly siliceous rocks with stilpnomelane, and foliated

(Metz, 1975). K-Ar ages ranging from 161 to 192 m.y. from Kodiak, Seldovia, and Knik River schists indicate that the development of the McHugh Complex. Four K-Ar ages on crossi (Table 1, locs. 31-32, 37-38) and one K-Ar age on muscovite (loc. 33) from blueschist and greenschist in the Valdez quadrangle range between 152 and 175 m.y. (Middle and Late Jurassic and also are significantly older than emplacement of the McHugh Complex. Two additional K-Ar ages on crossite (loc. 34, 36) able resetting, possibly during emplacement of the schistose rocks within the McHugh Complex. Decker and others (1980) Bay Group that range in age from 106 to 91 m.y. (or early La Cretaceous). These ages, they believe, indicats metamorphism during a "mid-Cretaceous" subduction svent in southeastern Alaska. Partial resetting of ages of schistose inclusions in cate the same subduction event in southern Alaska. Argon lo from the minerals of the sheared schistose rocks may not have been complete, but the youngest age may approach the time of accretion of the McHugh Complex. Amphibolite-facies metamorphic rocks - Between the Nelchina and Tazlina Glaciers in the McHugh Complex is an oval-shaped tectonic

by actinolite, chlorite, granular epidote, quartz, prehnite, carbonate, and clay minerals. Apparently the rocks were affected by the same prehnite-pumpellyite facies episode that metamorphosed their host, the McHugh Complex.

Amphibolite and orthogneiss - Metaplutonic rocks form almost the entire periphery of the large tectonic inclusion in the McHugh Complex. They are compositionally banded and range from dioritic gneiss. In places they contain enough relict pyroxene to qualify as gabbro, and they also contain lenses of pyroxenite as much as 2 m across. The foliation of the amphibolits and large hornblende crystals or pegmatitic hornblende-plagioclass pods have grown in the hinges of many folds.

Jig Layered quartz gabbro - A conspicuously layered quartz gabbro body occupies the core of the large tectonic inclusion in the

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U.S. GEOLOGICAL SURVEY

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FOLIO OF THE VALDEZ QUADRANGLE, ALASKA

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